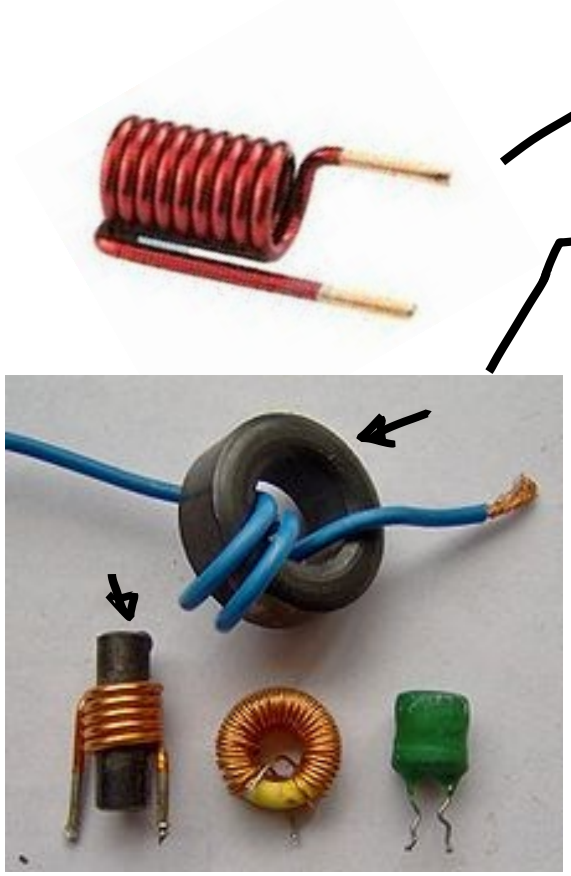
Inductors

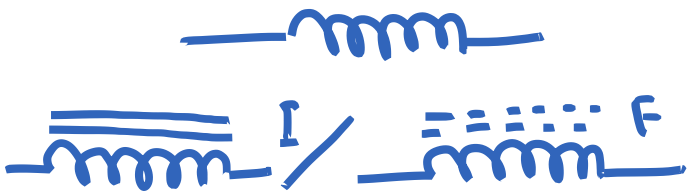
An inductor is a passive two-terminal electrical component that stores energy in a magnetic field when current flows through it.



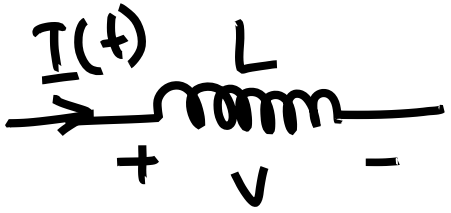
air cored inducter

iron/ferrite core inducter

Circuit Symbols



Characterized by its inductance (L)



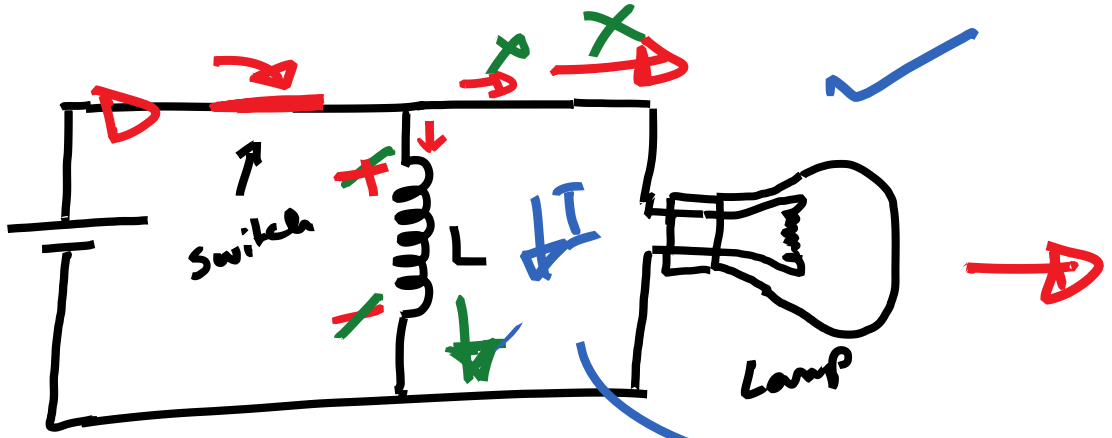
$$V = L \frac{dI(t)}{dt}$$

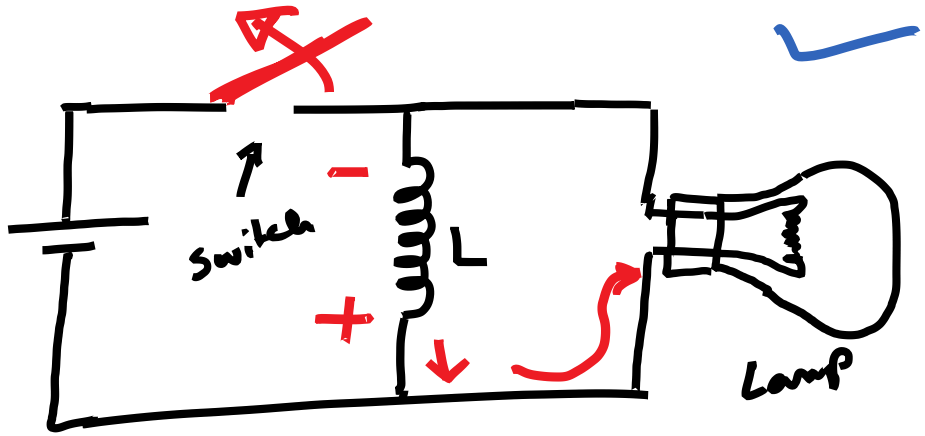
Henry, Amp, volt

$$L = \frac{V}{\frac{dI(t)}{dt}}$$

Image sources: www.semiconductorforu.com and wikipedia.org

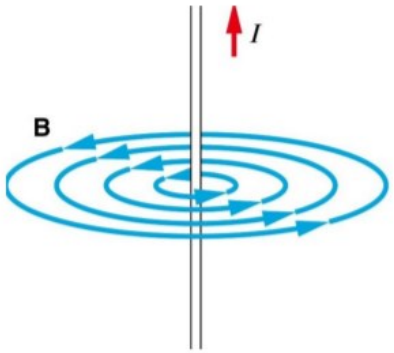
Inductors





Energy stored in inductor

$= \frac{1}{2} L I^2$



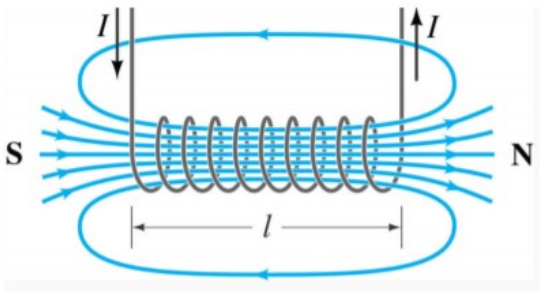
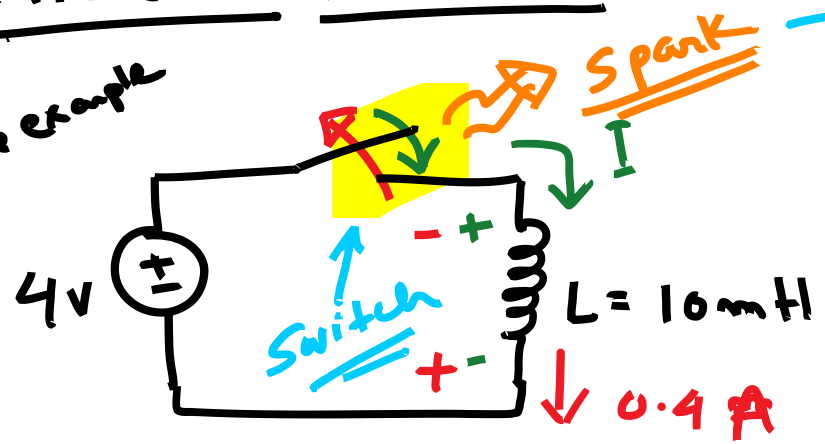


Image source: physics.olemiss.edu/

Inductors

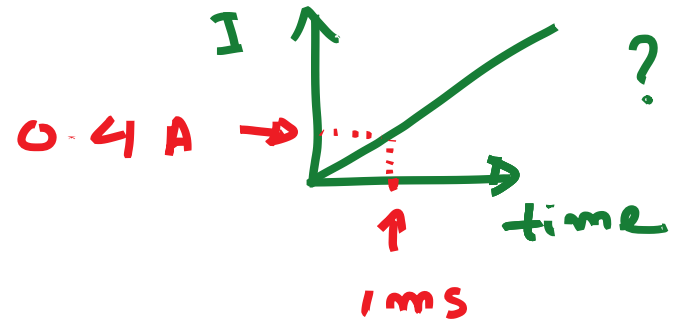
Inductor kick-back

Simple example



→ air breakdown

$$I = \frac{1}{L}\int_0^t V\,dt = \frac{1\times 4}{10\times 10^{-3}}t = 400t\ A$$

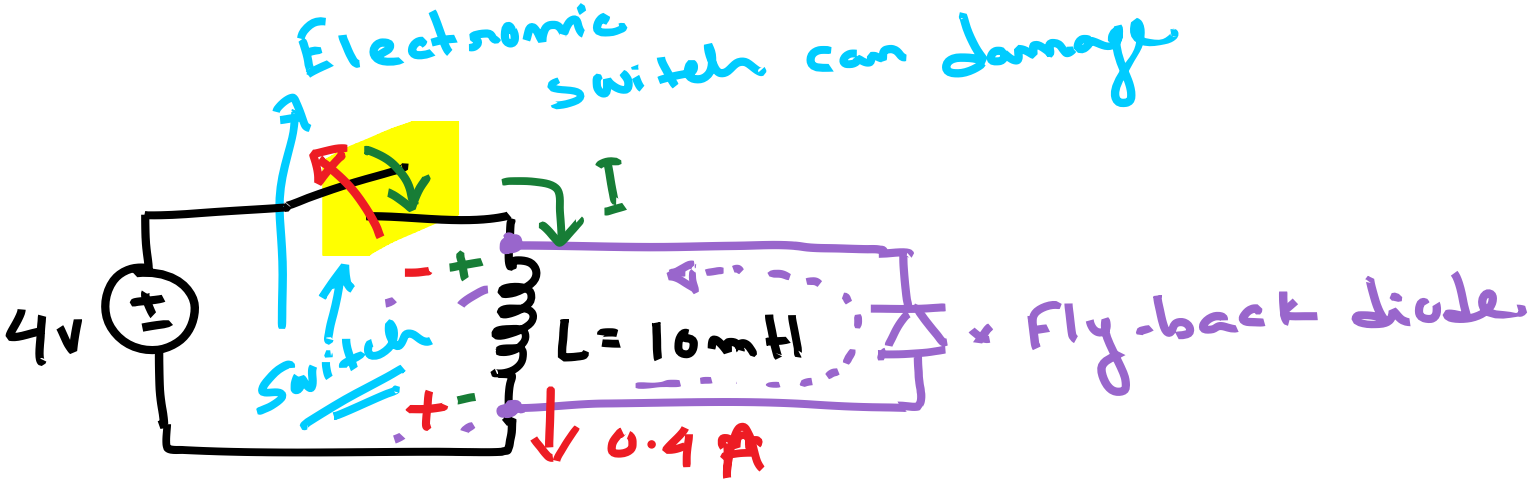


let, after 1 ms switch is opened.

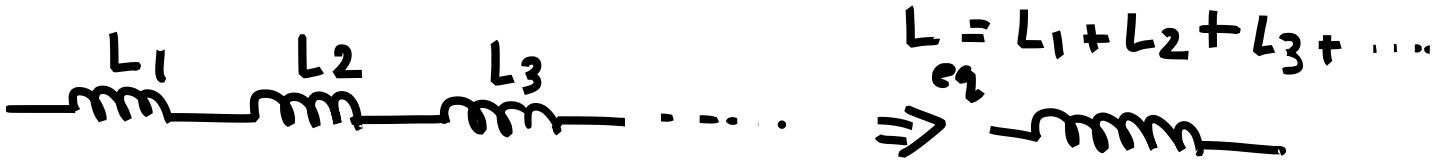
$$V_L = 10\times 10^{-3} \times \frac{0 - 0.4}{1\times 10^{-6}} \leftarrow dt$$

$$V_L = -4000\ V$$ → huge voltage

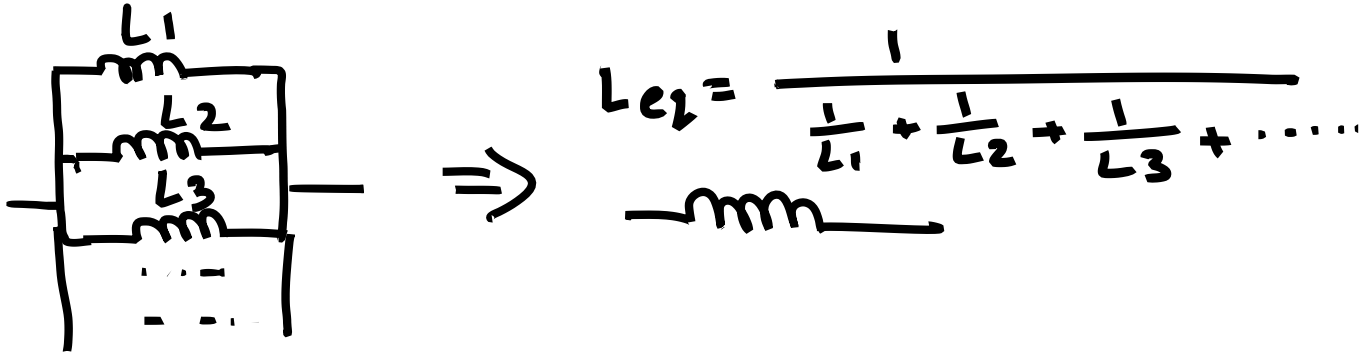
Inductors



Inductors in Series:

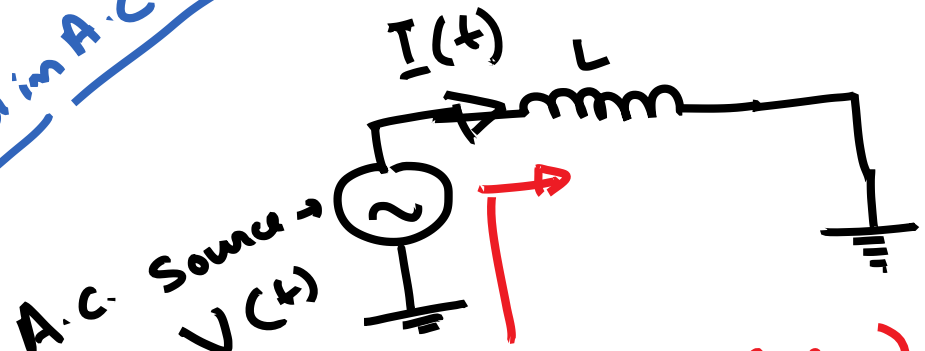


Inductors in parallel:



Inductors

Inductor in A.C. circuits



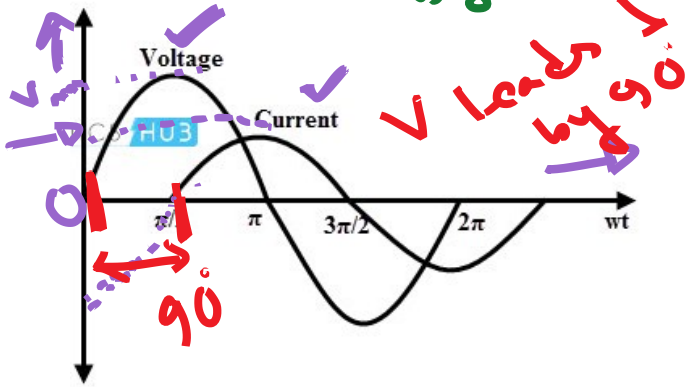
Reactance (X_L)

$$X_L = \omega L = 2\pi f L$$

(X_L: Ω, L: H, f: Hz, π: 3.14)

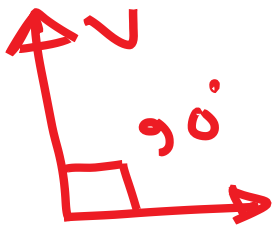
$$V(t) = V_m \sin \omega t \quad , \quad V = L \frac{dI(t)}{dt} \quad , \quad I(t) = \frac{1}{L} \int V \, dt$$

For L, Voltage leads current by 90°



$$I(t) = \frac{V_m}{\omega L} [-\cos \omega t] = \frac{V_m}{\omega L} \sin(\omega t - 90^\circ)$$

V leads I by 90°



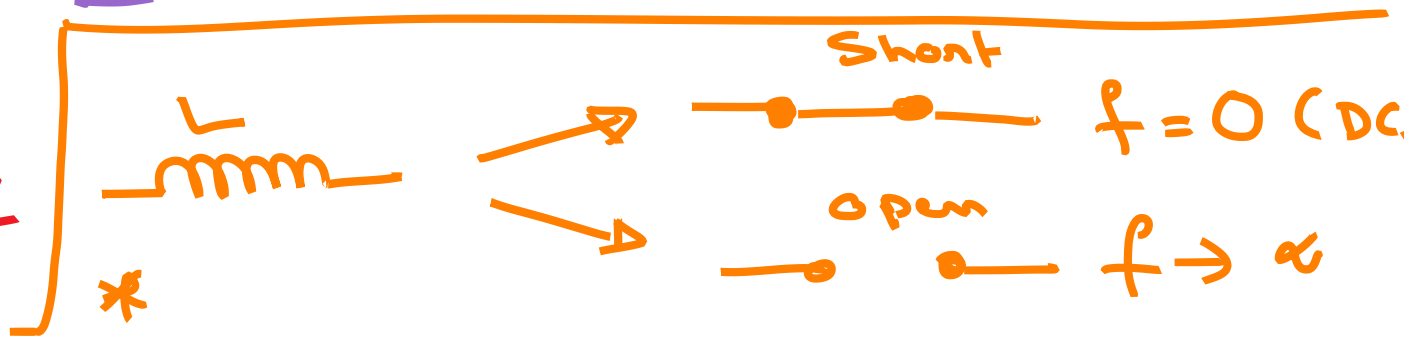


Image sources: www.electronicshub.org/

Diodes → two electrodes

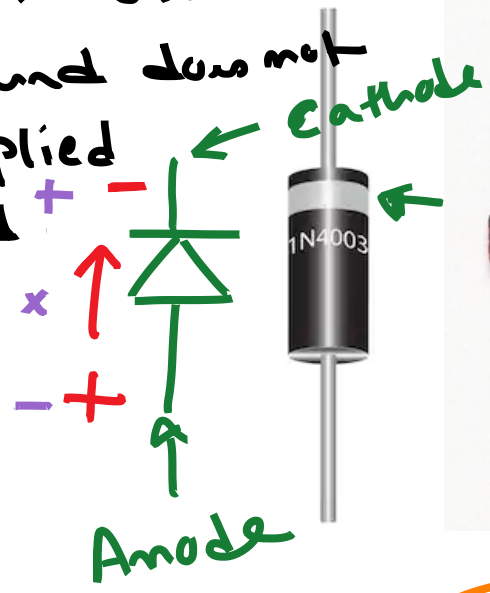
Diodes?

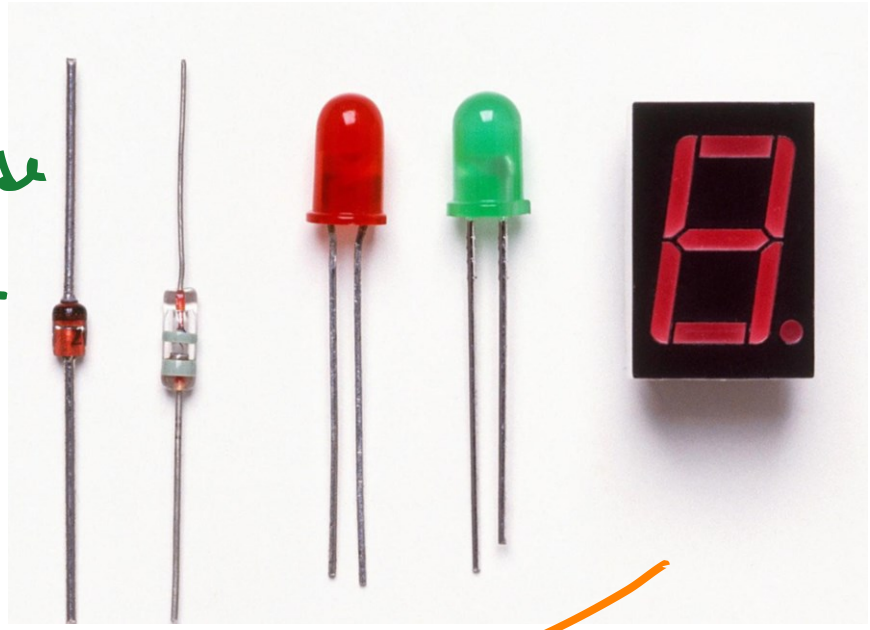
Two terminal device which conducts current in one direction and does not conduct when the voltage applied across the diode is reversed

Different types:

1. General purpose diodes
2. Zener diode
3. Light Emitting Diodes
4. Photo diodes etc..

circuit symbols





Semiconductor diode

Vacuum Tube diode →

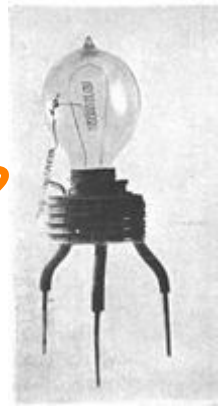
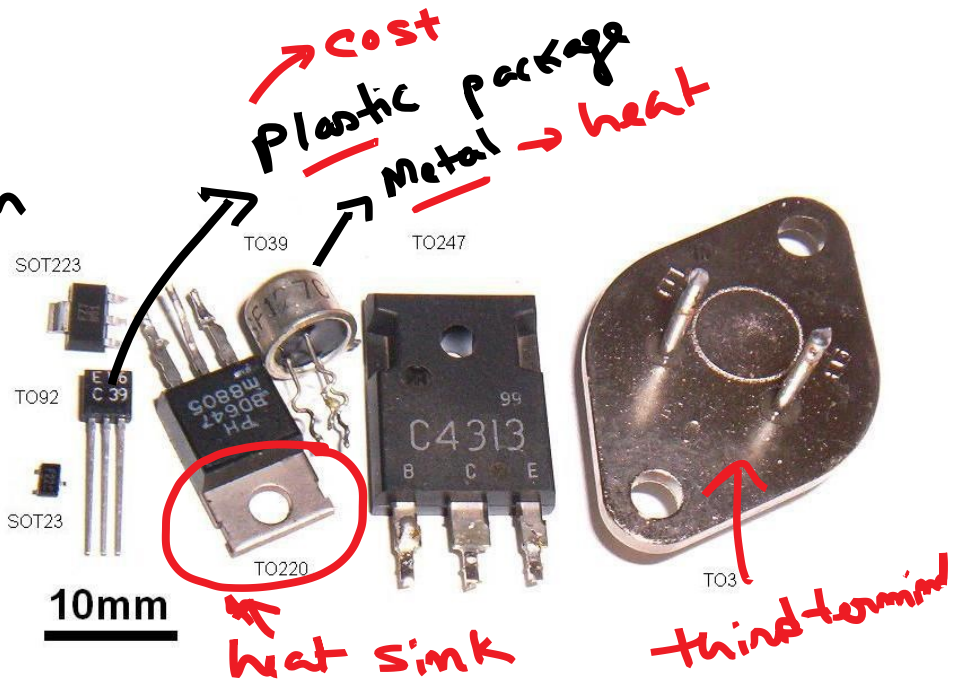


Image source: wikipedia.org, www.lifewire.com

Transistors

Transistor is a semiconductor device that can amplify a signal, can acts as a switch, and have at least three terminals.

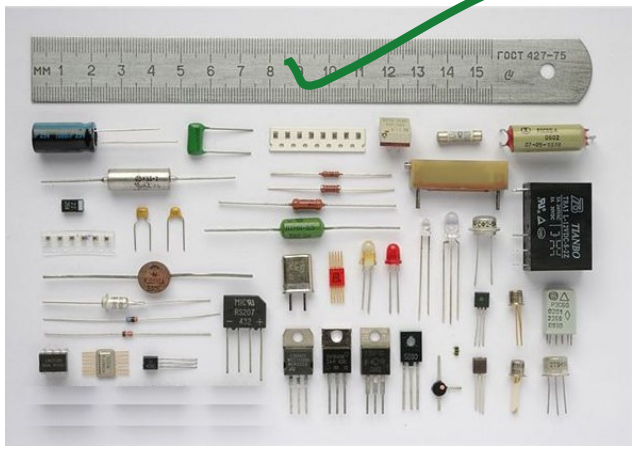


Transistors

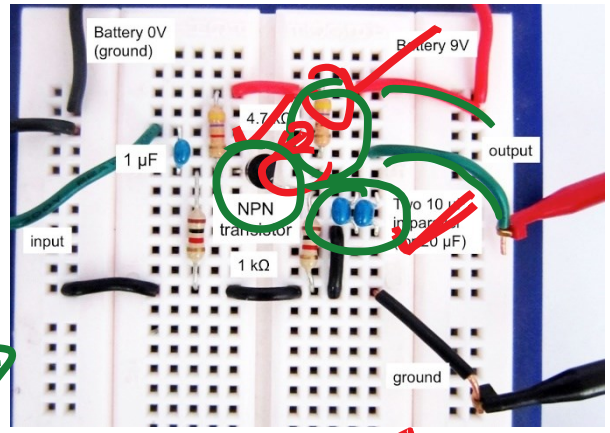
- Field Effect Transistors (FETs) ✓
  - [MOSFET, JFET, HEMT, etc.]
  - Unipolar (either electrons or holes)
  - Source (S), Drain (D) & Gate (G) ← Terminals
- Bipolar Junction Transistors (BJTs) ✓
  - Bipolar → Both electrons & holes participate in conduction.
  - Terminals: Emitter → E, Base → B, Collector → C

Image source: wikipedia.org

Circuits using discrete components vs Integrated Circuits (ICs)

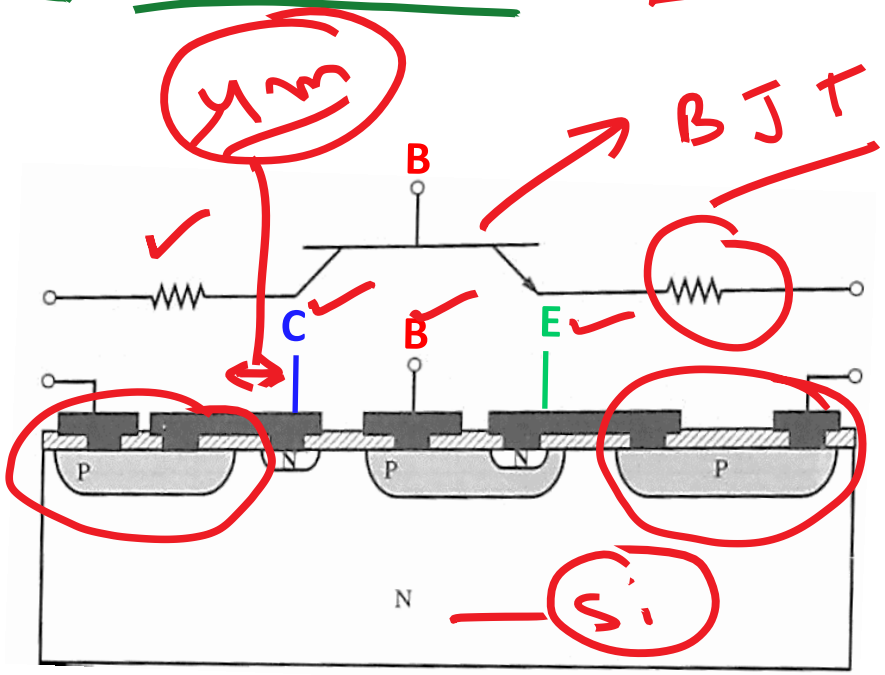


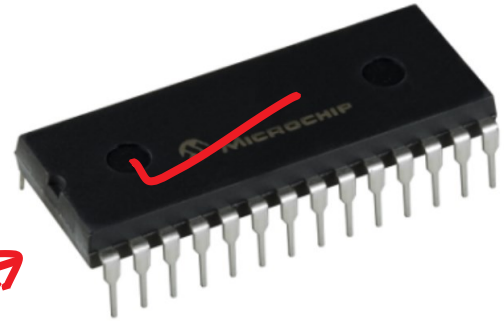
Discrete components 1*

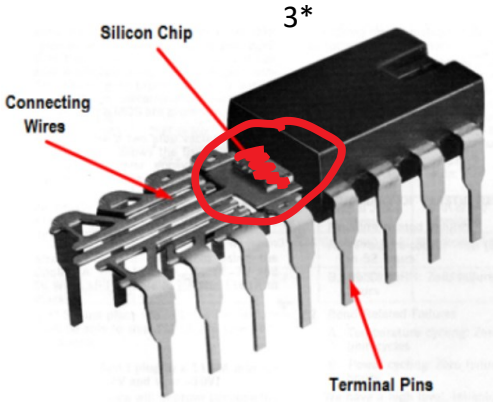


2*

Circuit using discrete components







3*

Integrated Circuit (IC)

Integrated Circuits

Integrated circuit is a set of electronic circuit on a small piece of semiconducting material primarily silicon. Integration of large number of electronic components (both active and passive) on a single chip results in reduction in size, cost and power consumption, and increase in operational speed and reliability.

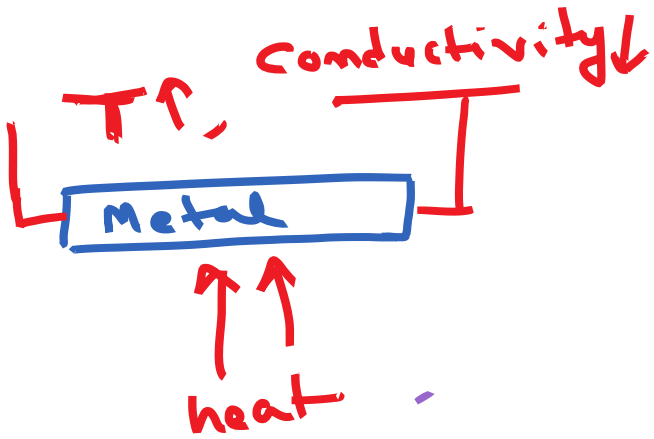
Image sources: [1*] wikipedia.com, [2*] backyardbrains.com, [3*] mphysicstutorial.blogspot.com

✓Semiconductors

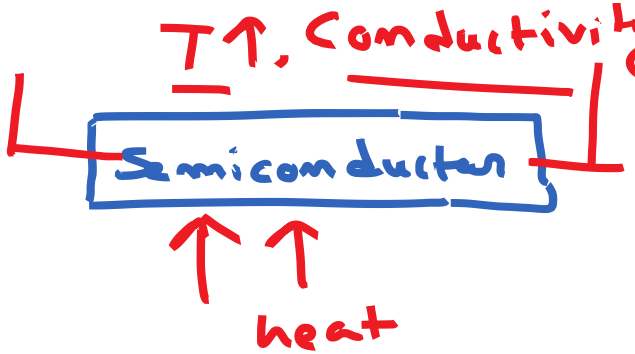
Materials (conductivity) → Metal (conductor)
→ Insulator
→ Semiconductor → electrical conductivity is between an insulator and a conductor

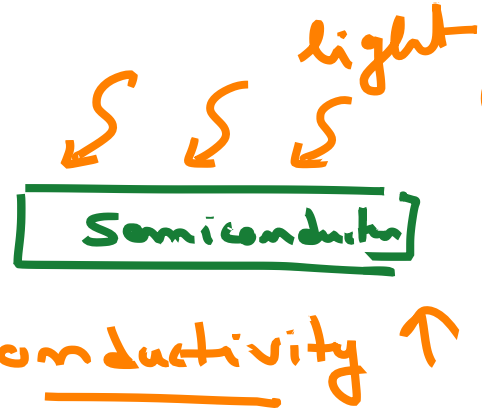
ex. glass, plastic ↓

ex. Metals



① *





② *

③ * Conductivity of a Semiconductor can be changed by orders of magnitude by introducing small amount of impurity in it

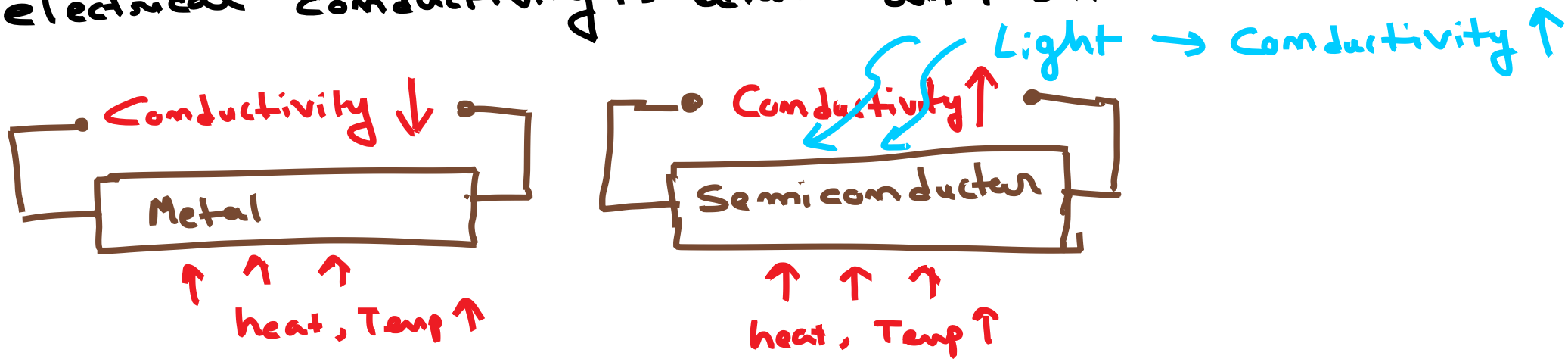
↓

" Doping "

✓ Semiconductors

Based on conductivity, Materials → Conductor (Metals, etc)
→ Insulators (glass, plastic, ...)
→ Semiconductor

= electrical conductivity is between an insulator and a conductor



* Conductivity of a Semiconductor can also be changed by Orders of magnitude by introducing a small amount of impurities in it.
→ "Doping"

Semiconductors

Charge carriers → electrons, holes*

↓

also in Metals

Electronic devices → Semiconductor [example: Silicon (Si), Germanium (Ge), ...]

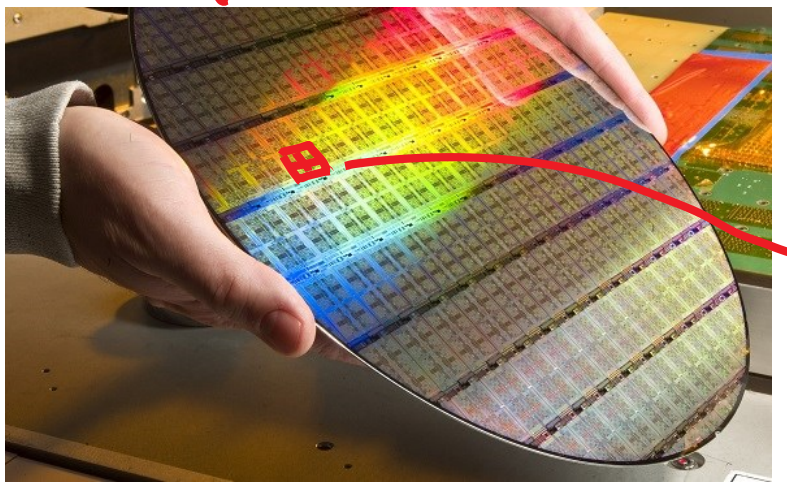
*

Sand

crystalline Si

Si wafers

Processed wafer



Packaged device

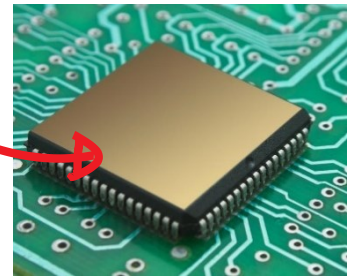


Image source: www.everythingrf.co, wikipedia.org, recofiltration.com, www.wisegeek.com